Development of a numerical wave flume for the study of scour protection around offshore monopile foundations under waves and currents

Arboleda Chavez Carlos Emilio, Wu Minghao, Stratigaki Vasiliki and Troch Peter

Coastal Engineering Research Group, Department of Civil Engineering, Ghent University, Technologiepark 904, 9000 Ghent, Belgium
E-mail: carlosemilio.arboledachavez@ugent.be

So far, the majority of the offshore wind turbines are supported by monopile structures. As any structure embedded in the seabed, erosion/scour may occur around the monopile foundations. In order to counter erosion, a scour protection is placed around the monopile's foundation on the sea bed. In this study, the behavior of the scour protection will be modeled using numerical tools.

De Vos et al. (2012) [1] give an overview of key experimental research carried out in the large wave flume of the Coastal Engineering Research Group - CERG - of Ghent University – UGent -, Belgium, regarding scour protection. Tests were carried out with a scale model (1:50) under the combined action of waves and currents. Three main failure modes have been distinguished: (i) damage of the scour protection by the flow, (ii) failure due to scour at the edge of the protection, and (iii) sinking of the scour protection.

The latter failure mode was studied by Nielsen et al. (2013) [2] and a numerical model for currents based on the Flow 3D software is proposed. This study concludes that a porous medium approach of scour protection can be used to determine the bed shear stresses underneath the scour protection, although calibration is needed.

Numerical models able to model the sinking failure of the scour protection around monopiles under the action of waves and currents using the porous medium approach are currently not available. The objective of this study is to cover this literature gap.

The toolbox selected for the development of the numerical model is OpenFOAM, Jasak (1996) [3], while the wave generation/absorption is performed using the module IHFOAM, Higuera (2015) [4]. In the latter module, the incompressible Volume Averaged Reynolds Averaged Naviers Stokes - VARANS - equations are solved in a finite volume discretization. In order to deal with the multi fluid (air, water) nature of the problem, the Volume of Fluid - VOF - method is used, which allows using the same set of equations to solve the momentum balance in both phases, thus, speeding up the calculations. The turbulence is modeled following the approach of Devolder et al. (2017) [5] as it has shown to reduce the turbulent kinetic energy production at the interface between the two fluids. Finally, the scour protection is considered as a porous medium as performed in Nielsen et al. (2013) [2].

The numerical model will be validated using experimental data. Physical model tests will be carried out in an upcoming European Hydralab+ project (spring 2018) which focuses on experimental modeling of scour protection around offshore wind turbine monopiles and is coordinated by CERG from UGent. The tests will be performed in the Fast Flow Facility in HR Wallingford with a scale of 1:8.33 and aim to extend and complement the 1:50 experiments performed by CERG (De Vos et al. (2012) [1]).

Acknowledgement

The work described in this publication was supported by the European Community's Horizon 2020 Research and Innovation Programme through the grant to HYDRALAB-PLUS, Contract no. 654110. The first author would like to acknowledge his PhD funding through a Special Research Fund of UGent, (BOF).

References

[1] De Vos, L., De Rouck, J., Troch, P., Frigaard P. 2012. Empirical design of scour protections around monopile foundations. Part 2: Dynamic approach. Coastal Engineering 60:286-298.
[2] Nielsen A. W., Liu X, Sumer B. M., Fredsoe J. 2013, Flow and bed shear stresses in scour protections around a pile in a current, Coastal Engineering 72:20-38

[3] Jasak H. 1996, Error Analysis and Estimation for the Finite Volume Method with Applications to Fluid Flows, PhD. Thesis, Imperial College, University of London
[4] Higuera P. 2015, Application of Computational Fluid Dynamics to Wave Action on Structures, PhD. thesis, Universidad de Cantabria
[5] Devolder B., Rauwoens P., Troch P. 2017, Application of a buoyancy-modified k-ω SST turbulence model to simulate wave run-up around a monopile subjected to regular waves using OpenFOAM, Coastal Engineering 125:81-94

Keywords: scour protection; offshore wind turbines; numerical modelling; porous flow; waves; currents

Book of Abstracts

VLIZ Special Publication 80

Book of Abstracts | VLIZ Marine Science Day | 21 March 2018 | MEC Staf Versluys | Bredene, Belgium

BOOK OF ABSTRACTS

VLIZ MARINE SCIENCE DAY

MEC STAF VERSLUYS, BREDENE
21 MARCH 2018

VLIZ SPECIAL PUBLICATION 80

This publication should be quoted as follows:

Jan Mees and Jan Seys (Eds). 2018. Book of abstracts – VLIZ Marine Science Day. Bredene, Belgium, 21 March 2018. VLIZ Special Publication 80. Vlaams Instituut voor de Zee – Flanders Marine Institute (VLIZ): Oostende, Belgium. 142 + ix p.

Vlaams Instituut voor de Zee (VLIZ) – Flanders Marine Institute
InnovOcean site, Wandelaarkaai 7, 8400 Oostende, Belgium
Tel. +32-(0)59-34 21 30 – Fax +32-(0)59-34 21 31
E-mail: info@vliz.be – Website: http://www.vliz.be

Photo cover: VLIZ

ISSN 1377-0950

PREFACE

This is the 'Book of Abstracts' of the 18th edition of the VLIZ Marine Science Day, a one-day event that was organised on 21 March 2018 in the MEC Staf Versluys in Bredene.

This annual event has become more and more successful over the years. With almost 400 participants and more than 100 scientific contributions, it is fair to say that it is the place to be for Flemish marine researchers and for the end-users of their research. It is an important networking opportunity, where scientists can meet and interact with their peers, learn from each other, build their personal professional network and establish links for collaborative and interdisciplinary research.

Marine scientists from all Flemish universities and scientific institutes – and representing all marine science disciplines – have contributed to this volume. The book thus illustrates the diversity, quality and relevance of the marine sciences in Flanders (and Belgium): it provides a beautiful and comprehensive snapshot of the state-of-the-art of marine scientific research in Flanders.

Pre-doc and post-doc scientists present their research in an exciting way and communicate their fascinating science – and its importance to society – to the wider public. We thus hope to demonstrate the excellence of Flemish marine science and to increase its national and international visibility.

The volume of research that is presented here holds a great promise for the future. It shows that marine science is a very lively discipline in Flanders, and that a new generation stands ready to address the grand challenges and opportunities that our seas and oceans represent.

For the second year, the Brilliant Marine Research Ideas are awarded, an initiative sponsored through the philanthropy scheme of VLIZ. We are proud to announce that last year's winners present their results here at the VLIZ Marine Science Day.

I want to congratulate all participants with their contributions, and I invite them all to become members of VLIZ and to actively participate in our events and activities in the future.

Bredene, 21 March 2018

Prof. Dr Jan Mees

General Director VLIZ

TABLE OF CONTENTS

Informative posters

Posters in competition